Northern States Power Company d/b/a Xcel Energy

03-73-TR-XCEL

IN THE MATTER OF XCEL ENERGY'S APPLICATION TO THE MINNESOTA ENVIRONMENTAL QUALITY BOARD FOR A ROUTE PERMIT FOR A 345 KV TRANSMISSION LINE FROM THE SPLIT ROCK SUBSTATION TO LAKEFIELD JUNCTION SUBSTATION AND A 115 KV TRANSMISSION LINE FROM NOBLES COUNTY SUBSTATION TO CHANARAMBIE SUBSTATION AND THE NOBLES COUNTY SUBSTATION

Direct Testimony

Of

Walter T. Grivna, P.E.

Manager Transmission Reliability Assessment – Minneapolis

(Xcel Energy Services Inc.)

February 14, 2005

BEFORE THE ENVIRONMENTAL QUALITY BOARD

OF THE STATE OF MINNESOTA

DIRECT TESTIMONY OF WALT T. GRIVNA

Q. Please state your name and business address.

A. My name is Walter T. Grivna. My business address is 414 Nicollet Mall – 6th Floor, Minneapolis, MN 55401.

Q. By whom are you employed and in what capacity?

A. I am employed by Xcel Energy Services Inc., the service company subsidiary of Xcel Energy Inc., as Manager Transmission Reliability Assessment – Minneapolis. Xcel Energy Inc. is the registered public utility holding company parent of Northern States Power Company d/b/a Xcel Energy (Xcel Energy or Company).

Q. Describe your educational background and current job responsibilities.

A. I received a Bachelor of Electrical Engineering from the University of Minnesota, Institute of Technology in 1977 and a Master of Business Administration from the College of St. Thomas in 1981. I started full-time with Xcel Energy (then NSP) as an engineer in 1977 and advanced to positions of increasing responsibility over my 27-year-tenure with the Company. I have held my current position since May 2002. My job responsibilities include supervising department engineers in planning the Xcel Energy, operating company electric transmission systems in Minnesota, Wisconsin, North Dakota and South Dakota and participating in Independent Transmission System Operator (MISO) studies and planning activities to ensure Xcel Energy Inc. meets its obligations under the MISO Open Access Transmission Tariff. I also oversee development of local and regional transmission system plans. A copy of my resume is attached as **Exhibit WG-1**.

Q. On whose behalf are you submitting this testimony?

A. On behalf of the applicant, Xcel Energy.

Q. What is the purpose of your testimony?

A. My testimony is intended to support Xcel Energy's application to the Minnesota Environmental Quality Board (MEQB) for a permit to construct a new 345 kV transmission line from the Split Rock Substation to the Lakefield Junction Substation, a new 115 kV transmission line from a new Nobles County Substation to the existing Chanarambie Substation and a new Nobles County Substation. More specifically, I am testifying in support of Xcel Energy's request to build a new 115 kV transmission line between the new Nobles County Substation and the Chanarambie Substation on single circuit structures for the majority of the route.

Q. Are you sponsoring any previously submitted testimony?

A. Yes. I am sponsoring the testimony of Richard Gonzalez, Principal Engineer of Transmission Planning at Excel Engineering, Inc., and a consultant to Xcel Energy. Mr. Gonzalez's testimony was submitted on February 3, 2005 to the MEQB at the hearing on Xcel Energy's Application for a Route Permit for a Buffalo Ridge-White 115 kV Transmission Line, 04-84-TR-XCEL, which testimony is attached as **Exhibit WG-2.**

Q. If I were to ask you all of the same questions that were asked of Mr. Gonzalez in his direct testimony, would you provide the same answers as Mr. Gonzalez provided?

A. Yes.

Q. Do you have anything you would like to add specifically relating to the propriety of using double circuit structures for the 115 kV transmission line between the new Nobles County Substation and Fenton Substations?

A. Yes.

Q. Please generally describe that additional information.

A. As Mr. Gonzalez explained, Xcel Energy has been actively studying what improvements are required to increase available transmission capacity in the Buffalo Ridge area beyond 825 megawatts to support additional wind

development. I have been working with Mr. Gonzalez on these study efforts, including the "Buffalo Ridge Incremental Generation Outlet" study. To date, study participants have identified limitations on the transmission system that need to be addressed before capacity can be increased. The main options to address these limitations are 1) construction of a second 115 kV transmission line between the Nobles County Substation and a new Fenton Substation to be built about the halfway point between the Nobles County Substation and the Chanarambie Substation near Lake Wilson and a new 115 kV transmission line from the existing Lake Yankton substation to a new substation on the City of Marshall's 115 kV transmission system and 2) an expansion of the first option to include construction of a second 115 kV transmission line between the new Brookings County Substation in South Dakota and a new Yankee Substation in Lincoln County. These options have led to a discussion of whether the MEQB should order double circuit structures along the portion of the 115 kV line route between the Nobles County and Fenton substations in this proceeding. This would not be advisable. While Mr. Gonzalez's testimony focused on the inadequacy of a double circuit 115 kV line between the new Yankee Substation and the new Brookings County Substation, the analysis applies equally to Nobles County-Fenton limitation that must be addressed. Available transmission capacity can only be increased in the area if the second 115 kV line between the Nobles County Substation and the Fenton Substation is built on separate poles because the failure of the first new line is the contingency that must be covered.

Q. Are you involved in the decision making process regarding whether a second 115 kV Nobles County-Fenton line or a second 115 kV Yankee–Brookings County line should be built?

A. Yes. As mentioned, I am involved in the study processes and monitor progress of the study processes and will help draft the final conclusions of the Buffalo Ridge Incremental Generation Outlet study. I am also part of the management group

that will select the option or options to be implemented.

Q. Has any decision been made regarding which transmission options are to be implemented as a result of the Buffalo Ridge Incremental Generation Study?

A. No. While the options of building one or two additional 115 kV lines between Yankee and Brookings County, and/or between Fenton and Nobles County, look promising, some additional study studies, including dynamic stability studies, are required before it can be determined that these lines would perform as needed.

Q. What is your opinion regarding the potential benefits of building the new 115 kV line using double circuit structures between the new Nobles County Substation and the new Fenton Substation?

A. A second 115 kV circuit between the Nobles County and Fenton substations is needed to provide redundancy for the first circuit, so as to achieve satisfactory post-contingency power system performance. If the second circuit were placed on double circuit structures, no incremental transmission outlet would be achieved. Consequently, it is very unlikely that the second circuit on the structures would ever provide any value to the system.

The only exception would be near the Fenton, Chanarambie and Nobles County substations, where there will be many 34.5 kV lines exiting the substations. By building short sections (less than one mile) of the lines capable of double circuiting, the number of structures in those areas could be reduced.

Q. Have you also been involved in evaluating the two 345 kV transmission line routes, the Interstate Route and the Alliant Route?

A. Yes.

Q. Do you have concerns regarding either of the two routes from a system perspective?

A. Yes. As explained in Xcel Energy's response to MEQB Request No. 11, during construction, the Alliant Route creates unacceptable increased reliability risks. I

assisted in drafting the response to MEQB Request No. 11, which is attached to the Direct Testimony of Grant D. Stevenson as Exhibit GS-1. I fully support that analysis and am available to answer questions.

Q. Does this conclude your testimony?

A. Yes it does.

Walter T. Grivna, P. E.
414 Nicollet Mall - 6th Floor
Minneapolis, MN 55401
(612) 330-6907

Experience

May 2002 To Present

Manager Transmission Reliability Assessment - Minneapolis

Xcel Energy Services Inc.

Responsibilities: Supervise department engineers in planning the Xcel Energy operating company electric transmission systems in Minnesota, Wisconsin, North Dakota and South Dakota. Oversee the development of local and regional transmission system plans, including coordinated joint planning with other utilities to ensure reliable transmission service to users of the Xcel Energy transmission system. This includes participating in MISO sponsored transmission service studies, interconnection studies, long range regional plan development, load service planning and other transmission planning activities required by MISO to perform it's obligations under the MISO OATT and the MISO agreement with the transmission owners. Provide technical support for regulating aspects of Xcel Energy Transmission System planning activities and contract development. Represent Xcel Energy at the MISO Planning subcommittee.

April 1999 To May 2002

Principal Planning Engineer

Xcel Energy Services Inc.
Northern States Power Company

Responsibilities: Provide strategic planning analysis and recommend company policies and initiatives for issues related to transmission system use and reliability. Represent the corporation at the Mid-Continent Area Power Pool Reliability Compliance Subcommittee (Chair 2000 and 2001) and MAPP at the NERC Compliance Review Subcommittees.

December 1994 to April 1999

Geographic Planning Leader

Northern States Power Company

Responsibilities: December 1994 through June 1996: supervised five department engineers in planning for 7000 MW transmission and distribution system. December 1994 through April 1999 provide technical analysis and support for planning the transmission and distribution system, regulatory aspects of NSP's transmission and distribution planning activities and contract development. Coordinate planning activities with neighboring utilities over five state area. Provide strategic planning analysis and develop company policies and initiatives for issues related to transmission and distribution system use and system reliability.

July 1986 to December 1994

Superintendent, Transmission Planning

Northern States Power Company

Responsibilities: Supervised five department engineers in planning for a 7000 MW transmission system with voltages from 69,000 to 500,000 volts. Coordinated planning activities with neighboring utilities over five state area. Developed company policies for areas related to transmission use and system reliability. Administered the $30 million annual department capital budget. Developed strategies for transmission joint use contracts and equities (payment responsibilities), and provided economic analysis of the various proposals. Drafted contracts covering various agreements negotiated by the department. Drafted testimony for regulatory proceedings concerning areas of department responsibility. Acted as company expert witness in condemnation proceedings before regulatory bodies.

November 1989 to April 1990

Superintendent, Operations Coordination

Northern States Power Company

Responsibilities: Supervised outage coordination and security analysis activities. Developed operating procedures. Reviewed new project design for appropriate operations. System

Operations on corporate task forces.

June 1977 to July 1986 — Engineer, Assistant Planning, Associate Planning, Planning, and Senior Planning Engineer

Northern States Power Company

Responsibilities: Planned for future transmission requirements and recommended projects for construction. Represented Northern States Power in and led joint utility transmission planning studies. Utilized PSS/E power flow program. Developed and recommended negotiating strategies in equity negotiations with neighboring utilities. Performed Generations and Power Purchase financial analysis, assisted in negotiating strategy development and Draft Power Purchase and Generation Purchase contracts.

June 1975 to June 1977 — Engineering Intern

Northern States Power Company

Education

Bachelor of Electrical Engineering — June 1977
University of Minnesota, Institute of Technology

Master of Business Administration — May 1981
College of St. Thomas

Registration

Registered Professional Engineer in Minnesota since July 1982

Organizations

IEEE
Power Engineering Society

Northern States Power Company d/b/a Xcel Energy

04-84-TR-XCEL

IN THE MATTER OF XCEL ENERGY'S APPLICATION TO THE MINNESOTA ENVIRONMENTAL QUALITY BOARD FOR A ROUTE PERMIT FOR A BUFFALO RIDGE-WHITE 115 KV TRANSMISSION LINE

Direct Testimony

Of

Richard Gonzalez
Principal Engineer, Transmission Planning
Excel Engineering, Inc.
February 3, 2005

WG - 2

BEFORE THE ENVIRONMENTAL QUALITY BOARD

OF THE STATE OF MINNESOTA

DIRECT TESTIMONY OF RICHARD GONZALEZ

Q. Please state your name and business address.

A. My name is Richard Gonzalez. My business address is 500 73rd Avenue NE, Suite 119, Fridley, Minnesota 55432.

Q. By whom are you employed and in what capacity?

A. I am employed by Excel Engineering, Inc. as Principal Engineer, Transmission Planning.

Q. Briefly describe your professional experience.

A. I graduated from the University of Minnesota in 1982 with a Bachelor of Electrical Engineering degree. From 1983 to 1984 I was a Planning Engineer in the Division of System Engineering, Western Area Power Administration, Golden, Colorado. From 1984 to 2003 I was an engineer in the Delivery System Planning and Engineering Department at Northern States Power Company [now d/b/a Xcel Energy (Xcel Energy)] and was the principal planning engineer on the studies that resulted in the Public Utilities Commission March 2003 Order granting a Certificate of Need for Xcel Energy to construct four new high voltage transmission lines in western Minnesota to increase available transmission capacity for wind generation. I am presently a Principal Engineer and Partner at Excel Engineering, Inc., an independent electrical engineering consulting firm. In these positions I have been responsible for electric transmission system technical and economic analysis. This includes load forecasting, power system modeling, development and economic evaluation of options, and formulation of designs and specifications for new and upgraded transmission facilities. Exhibit RG-1 provides further details regarding my education and experience.

Q. Are you currently involved with assisting Xcel Energy in designing additional transmission improvements to further serve wind generation in Southwestern Minnesota?

A. Yes, as a consultant to Xcel Energy.

Q. Please describe Xcel Energy's efforts and your role.

A. Transmission improvements presently underway on the Buffalo Ridge (825 MW projects) include the addition of a Nobles County-Fenton-Chanarambie 115 kV line, and a Buffalo Ridge-Yankee-Brookings County 115 kV line which is being routed in this proceeding. These lines provide outlet from the Buffalo Ridge area generation sites to the new Nobles County and Brookings County 345/115 kV substations, which in turn provide access to the 345 kV transmission system.

Xcel Energy has recognized that there is further interest in wind generation development beyond the 825 MW level. Accordingly, in late 2004, Xcel Energy initiated the "Buffalo Ridge Incremental Generation Outlet" study. I am the lead engineer for this study effort which is exploring how to increase transmission capacity from the Buffalo Ridge after these 825 MW improvements are completed. We are analyzing the system not as it exists today, but as it will exist when the four new lines authorized by the Certificate of Need in March 2003 are energized. The principal goal of this Buffalo Ridge Incremental Generation Outlet transmission study is to identify feasible transmission options for increasing available transmission capacity from the Buffalo Ridge by several hundred megawatts.

Q. What transmission options have study participants identified to date?

A. Over a dozen transmission options have been formulated and evaluated. From this group, the options identified as top candidates to address study goals all involve construction of a second Nobles County-Fenton 115 kV line, and possibly also a second Yankee-Brookings County 115 kV line. These results have prompted questions about whether it might be desirable to construct the Nobles County-Fenton and Yankee-Brookings County 115 kV lines with double-circuit structures.

Q. If a second Yankee-Brookings County 115 KV line were placed on the same structures as the 115 kV line being routed as part of this proceeding, would available transmission capacity be increased?

A. No.

Q. Why not?

A. Double-circuit transmission lines are appropriate under certain circumstances, specifically for applications where high power handling capacity is required and where the transmission system is designed to withstand failure of both circuits. These are not the circumstances present in this instance. Therefore, constructing two lines on the same structures would not increase available transmission outlet capacity from the Buffalo Ridge area.

Q. What are the limitations that need to be addressed to increase available transmission capacity in the area?

A. Following completion of the 825 MW set of Buffalo Ridge area transmission improvements, among the most severe contingencies with respect to limiting generation outlet capability are those involving loss of either of the 115 kV outlet paths to the 345 kV system: Nobles County-Fenton and Yankee-Brookings County 115 kV. Outage of either line, or its associated 345/115 kV transformer (at Nobles County or Brookings County) presents two limitations: 1) overload of other transmission lines or transformers and 2) voltage collapse at Yankee or Fenton. Both limitations must be addressed before available transmission capacity from the Buffalo Ridge will be increased.

Q. Please describe the overload and voltage concerns.

A. With respect to overloads, in the Buffalo Ridge Incremental Generation Outlet Study the following "thermal" limiters were among those identified for the 825 MW system:

Buffalo Ridge Area Generation Outlet, MW	Limiting Facility	Contingency
1134	Pipestone-Pathfinder 115 kV	Nobles Co-Fenton 115 or Nobles Co 345/115 tx
1231	Nobles Co 345/115 tx	(system intact)
1239	Lyon Co-Yellow Med 69	Noble Co-Fenton 115 or Nobles Co 345/115 tx
1313	Nobles Co 345/115 tx	Yankee—Brookings County or Brookings County 345/115 tx
1347	Minn Valley-Yellow Med 69	Nobles Co-Fenton 115 or Nobles Co 345/115 tx
1363	Marshall-Erie Rd 115	Nobles Co-Fenton 115 or Nobles Co 345/115 tx
1373	Chandler-Chandler Tp 69	Nobles Co-Fenton 115 or Nobles Co 345/115 tx
1403	Lk Yankton-Buffalo Ridge 115	Yankee – Brookings County 115 or Brookings County 345/115 tx
1404	Marshall Tp-Granite Falls 115	Nobles Co-Fenton 115 or Nobles Co 345/115 tx

From this table it is evident that the Nobles County Fenton 115 kV and the Yankee-Brookings County 115 kV lines are critical elements of the Buffalo Ridge generation outlet infrastructure, and that outage of either circuit results in overloads on many other lines and transformers when generation is increased beyond the 825 MW level.

Voltage stability concerns are also a limiting condition with respect to the installation of additional wind generation in the Buffalo Ridge area. The 825 MW facilities were designed to accommodate 400 MW of new generation on the Buffalo Ridge, presumed to be approximately 50% (200 MW) on the northern portion of the Ridge (Yankee Substation) and approximately 50% (200 MW) on the southern portion (Fenton Substation). Current demand already has outstripped these predictions. Presently there are requests in the Interconnection Queue of the Midwest Independent Transmission System Operator (MISO) totaling 500 MW at Yankee and well over 200 MW at Fenton/Chanarambie.

Buffalo Ridge "Group 2" interconnection studies performed by MISO to address these requests indicate a post-contingent dynamic stability problem for the Yankee generation additions. The critical contingency is loss of the Yankee-Brookings County 115 kV circuit. This loss of access to the Brookings County 345/115 kV outlet causes high reactive power consumption on the remaining lines in the vicinity of the Yankee and Buffalo Ridge Substations. Subsequent detailed analysis performed by Xcel Energy as part of the Buffalo Ridge Incremental Generation Outlet Study has determined that the "stability" limitation identified by MISO is actually a "voltage stability" limitation. Following outage of the new Yankee-Brookings County 115 kV line, at Yankee generation levels higher than approximately 250 MW, there is inadequate reactive power supply available to maintain normal voltage levels and voltage collapse occurs. This means that interconnections at Yankee must be limited to fewer than 250 MW. A similar situation is present at Fenton, for loss of the Nobles County-Fenton 115 kV line.

Q. **What is the solution study participants have identified?**

A. Another path from Yankee to Brookings County is optimal because the outage of the new Yankee-Brookings County 115 kV line is the contingency that must be addressed. If a second Yankee-Brookings County 115 kV circuit were installed

on structures physically separate from the first circuit, the desired Yankee-Brookings County redundancy would be achieved and both voltage stability and post-contingency overload issues would be effectively addressed.

Q. **Why is it that these needs cannot be met by a second circuit on the same structures?**

A. If a second Yankee-Brookings County 115 kV circuit were installed on the same structures, the voltage stability and overload issues would remain because planning standards require that both circuits of a double circuit line be considered out at the same time. This is because when circuits are placed on common structures, both circuits are subject to the same failures. The primary common-mode failures for multiple-circuit transmission lines, all of which have been experienced on Xcel Energy transmission lines, are

- electrical failure of line insulation due to lightning strike;
- mechanical failure of one or more structures;
- broken shield wire falling into power conductors;
- wind-blown debris causing conductor-conductor short circuits;
- insulator contamination due to road salt, soot, or agricultural chemicals;
- contact with aircraft or construction equipment; and
- protective relaying malfunction ("sympathetic tripping" due to fault on adjacent circuit)

Q. Are there planning standards that apply to these common-mode contingencies?

A. Yes.

Q. What are those standards?

A. North American Electric Reliability Council (NERC) Planning Standards apply. Also, as a member of the Midwest Reliability Organization (MRO) (the successor NERC Reliability Region to the Mid-Continent Area Power Pool (MAPP) Reliability Council), Xcel Energy must meet MAPP Planning Standards in the Xcel Energy region.

Q. How do the NERC Planning Standards address double circuit lines?

A. The NERC Planning Standards for electric transmission systems consider loss of a double-circuit line as a "Category C" event: "Event(s) resulting in the loss of two or more (multiple) elements". Specifically, Contingency type C-5 is defined as "[a]ny two circuits of a multiple circuit towerline". For such contingencies, it is required that system stability be maintained, voltages and facility loadings be within applicable ratings, and that no cascading outages of generation or transmission elements result. The MISO Buffalo Ridge Group 2 interconnection study showed that outage of the Yankee-Brookings County 115 kV line resulted in power system performance criteria violations. Giving proper consideration to the NERC Category C-5 definition, it is clear that if the second Yankee-Brookings County 115 kV circuit were installed as a second circuit on the same structures as the first circuit, both circuits would be presumed to fail simultaneously, and there would be no performance improvement attained to address the identified deficiency.

Q. What are the MISO and MAPP Planning Standards that apply?

A. Xcel Energy/NSP is a member of the MRO, the successor NERC reliability region to MAPP. The MRO has adopted the MAPP Planning Standards for the former MAPP Members during its transition to establishing its own MRO-wide reliability standards. Consequently, Xcel Energy is subject to the present-day MAPP Planning Standards.

The MAPP Planning Standards are based upon the NERC standards, with certain extensions and clarifications added. Specifically, MAPP defines a double-circuit line as "[t]wo bulk transmission circuits constructed on common structures for a cumulative distance of more than one mile in length." [MAPP Reliability Handbook, Section 3 (revised December, 2004) http://www.mapp.org/content/reliabilityhandbook.shtml

Q. Please generally describe the one-mile exception to the definition of double-circuit line.

A. The "one-mile" exception is based primarily on the following probabilistic considerations.

- Some double-circuiting is often necessary for short segments adjacent to substations due to congested conditions, particularly in the case of large substations with many transmission circuits. Such exposures are typically on utility-controlled property, where conditions of maintenance and surveillance are superior.
- Review of performance records shows that for short lines (less than 3 or 4 miles) transmission circuit outages are more often caused by substation equipment problems than by actual line failure. Consequently, for short lines the additional outage exposure added by up to 1 mile of double circuit is judged acceptable. In contrast, for longer lines, the substation equipment contribution to unavailability is small, and the exposure contribution from double-circuit mileage quickly becomes significant for both of the two circuits involved.

Q. Is Xcel Energy required to adhere to the one-mile rule?

A. Yes. In accord with the MAPP/NERC Planning Standards, Xcel Energy's design of proposed transmission and generation additions is based on considering failure of double-circuit lines of over 1 mile in length as a single contingency.

Q. What is your opinion regarding the potential benefits of building the new Yankee-Brookings County 115 kV line using double circuit structures?

A. I do not believe that utilizing double circuit structures would be prudent because it is unlikely that a second circuit would be placed on the same poles. While installation of a second circuit on the same structures could be accomplished fairly quickly, there would be no incremental outlet benefit attained. To increase transmission capacity, a second circuit is needed to provide redundancy for the first circuit, so as to achieve satisfactory post-contingency power system performance. Considering the significant potential for common-mode failures, installation of the second circuit on the same structures as the first circuit would

not yield the desired increases in Buffalo Ridge generation outlet capability. Consequently, double-circuit construction is not appropriate or advisable for the Yankee-Brookings County and Nobles County-Fenton 115 kV circuits.

Q. Does this conclude your testimony?

A. Yes.

RICHARD GONZALEZ, PE
Excel Engineering, Inc.
500 73rd Avenue NE Fridley, Minnesota

Experience

2003-present	Principal Engineer Transmission Planning Excel Engineering Inc., Fridley, MN
1984-2003	Engineer I/Engineer II/Planning Engineer/Superintendent/Principal Engineer Delivery System Planning & Engineering Northern States Power Company, Minneapolis, MN
1983-1984	Engineer Division of System Engineering; System Studies Branch Western Area Power Administration, Golden, CO
1980-1982	Engineering Intern Student Power Supply Planning Northern States Power Company, Minneapolis, MN

Education

Bachelor of Electrical Engineering, University of Minnesota Institute of Technology, 1982

Additional technical/business coursework at University of Minnesota and University of Colorado:

- Statistics
- Business Law
- Engineering Economics/Accounting
- Semiconductor power electronic circuits
- Quality control and reliability
- Fluid mechanics
- Heat transfer
- Surveying
- Measurement techniques and data acquisition

Licenses

Licensed Professional Engineer, State of Minnesota (# 18938)
Class A Master Electrician, State of Minnesota (# AM01282)
Electrical Contractor, State of Minnesota (# CA02012)
Commercial Radiotelephone Operator (with radar endorsement),
Federal Communications Commission (# PG-16-19197)
Amateur Radio Operator (Extra Class), Federal Communications Commission

EXHIBIT RG - 1

Supervision of Technical Studies

Manitoba-Minnesota Transmission Upgrade (MMTU) Project Technical Studies (1989-1993, multiple utilities)
EPRI Research Project RP3012-18 (Evaluation of Thyristor-Controlled Series Compensation). Definition of project scope, review of contractor (Ontario Hydro) study results.
Measurement of Sherburne County Generating units' subsynchronous frequency response: selection, scheduling, supervision, review of contractor (Power Math Associates, San Diego, CA) measurements and technical analysis.
Subsynchronous Resonance Analysis of the MMTU Project: selection, supervision, review of contractor (General Electric Company, Schenectady, NY) technical analysis.
Exciter Instability Study of Angus C Anson generating Plant: coordination of on-line testing; selection, supervision, review of contractor (EUMAC Inc, Phoenix, AZ) technical analysis.
Statistical Analysis of Wisconsin Northern Area Winter peak load sensitivity to temperature: selection, supervision of statistical consultant (Prof. S Weisberg, University of Minnesota).
MISO Transmission Service Request (TSR) Studies (various).
Generation Siting Studies (baseload and peaking) (various)
Central North Dakota-Manitoba 230 kV Interconnection Study (1998).
Southwest Minnesota/Southeast South Dakota Electric Transmission Study (2001)

Publications

"Manitoba-Minnesota Transmission Upgrade Project", *Transmission & Distribution*, May 1992.
"Evaluation of FACTS Technologies' Application to the Manitoba-Minnesota Transmission Interface", (IEEE Special Publication: *Current Activities in FACTS Technologies*), 1992.
"Recommended Practice for Modelling of Static VAR Compensators", (Contributor) IEEE publication.
"500 kV Series Compensation Project", (Co-Author) EEI Electrical Systems and Equipment Committee, October, 1992.
"Application of Fast-Switched Shunt Capacitors to Improve Power System Dynamic and Steady-State Performance", (Co-Author), American Power Conference (Chicago, IL 1995).
"Transmission Outlet Cost Minimization Strategies for Wind-Electric Generating Facilities", American Wind Energy Association (Austin, TX 1997)
"Probabilistic Planning of Shunt Reactive Installations: Application of Binomial Probability Distribution Function to Prediction of Aggregate Shunt Reactive Compensation Availability and Determination of Spares Requirement", American Power Conference (Chicago, IL 1997)
"Solid Dielectric 115 kV Direct-Buried Cable Applied Within Substation Enables Conversion to Ring Bus Configuration to Meet Enhanced Reliability Needs", American Power Conf. (Chicago, IL 1997)
"Statistical and Engineering Analysis of Transmission System Topology's Influence on Large Autotransformer Failure Rates", (Lead Author), American Power Conference (Chicago, IL 1997)
"Developing a Long-Range Bulk Transmission System Plan for Northern States Power" (Co-Author), American Power Conference (Chicago, IL 1997)
"Why FACTS Devices May Not Achieve Widespread Use", Minnesota Power Systems Conference, October, 1997.

"Recent NSP Experience with Application of Mechanically-Switched Shunt Capacitors to Improve Power System Dynamic and Steady-State Performance", IEEE "FACTS Applications" IEEE Special Publication, 1996.

"Stepped Capacitor Applications: Design of Multi-Stage 115 kV Shunt Capacitor Bank", Minnesota Power Systems Conference, October, 1996.

"Approach to Modeling Utility Network for Harmonic Impedance Analysis", (Co-author), Minnesota Power Systems Conference, October, 1996.

"Voltage Stability Issues and Analysis Methods as Applied to Reactive Compensation Requirements of Red River Valley Electric Transmission System", Minnesota Power Systems Conf., October, 1995.

"Application of Fast-Switched Shunt Capacitors to Enhance Power System Dynamic and Steady-State Performance", (Co-Author), North American Power Symposium (Massachusetts Institute of Technology, November, 1996).

"An Exploration of Utility Concerns Due to Wind Electric Generation" (Co-Author) University of Minnesota, June, 1996.

"Semiconductor-Based Power Control is Exciting, but Evolutionary Enhancements to Conventional Devices Render them More Practical", The Future of Power Delivery in the 21st Century, (EPRI Conference; La Jolla, CA, November, 1997).

"Recent Storm-Induced Transmission Facility Outages in Minnesota Imposing Operating Challenges on Bulk System Reliability and Performance" (Co-Author) American Power Conference (Chicago, IL 1998)

"Transmission System Shunt Capacitor Banks: Recent Advances in Control Concepts and Switching Equipment Yield Improved Application Flexibility and Performance", Minnesota Power Systems Conference, October, 1998.

Industry Groups/Seminar Participation

Presenter, IEEE Winter Power Meeting, New York (1992, 1995)
Presenter, MAPP Engineering Conference (1992)
Presenter, Minnesota Power Systems Conference (Univ. of MN; 1991, 95, 96, 97, 98, 2001, 03, 04)
Presenter, EEI System Planning Committee (1992)
Presenter, EPRI Flexible AC Transmission Systems (FACTS) Workshop (1990)
Presenter, North Central Electric Association, 1997
Presenter, Iowa State University Power System Operators' Short Course (1999, 2003)
Panelist, "Living with Wind" session, IEEE Power Engineering Conference, Dallas, TX (2003)
Participant, EPRI/NERC Voltage Stability Forum (1992)
Participant, "Probabilistic Methods Applied to Power Systems" Symposium
Participant, EPRI "Power System Planning & Operations Voltage/VAR Projects" Symposium
Participant, EPRI "Non-Linear Dynamics" Seminar (1993)
Coordinator, Power System Voltage Stability Seminar (1994)
Member, Electrical Section, National Fire Protection Association (National Electrical Code Sponsor)
Member, Institute of Electrical and Electronics Engineers (IEEE), Power Engineering Society
Past Member, Mid-Continent Area Power Pool Design Review Subcommittee
Past Member, Mid-Continent Area Power Pool, Transmission Studies Task Force
Past Member, Electric Power Research Institute, Industry Advisory Panel RP1208 (Extended Transient/Mid-Term Stability Program)
Past Chair, Mid-Continent Area Power Pool Red River Valley Sub-regional Planning Group

Other Presentations

MAPP Design Review Subcommittee (Multiple)
EPRI Industry Advisors' Meeting (project RP3022: Evaluation of Thyristor-Controlled Series Compensation) (multiple)
IEEE Power Engineering Society (Twin Cities)
NSP Engineers' Association (multiple)
Manitoba-U.S. Tie Line Coordinating Committee (1994)
American Power Dispatchers Association (1994)
Missouri Basin Systems Group Planning Committee (1994)
EPRI "FACTS" System Studies Project Review (1993)

Testimony in Legal & Regulatory Proceedings

Certificate of Need/Route Certification for transmission lines and substations (States of MN & WI)
Local transmission permitting proceedings
Certificate of Need for generation facilities (State of MN)
Corporate Merger (FERC)
Presidential Permit (DOE) for U.S.-Canada interconnection upgrades
Right-of-way condemnations
Personal Injury lawsuit—electrical shock/burn

2-1-2005